FIRST DEVELOPMENT OF MUSCLE IN THE EMBRYO OF THE CHICK AND MAN.

By M. L. Holbrook, M. D., New York, N. Y.

Striped muscles arise like other tissues from the earliest indifferent or medullary tissue. It is a well-known fact that in the embryo of the chick the first striped muscles appear in the so-called muscle plates, where, especially in the transverse sections, we have an excellent opportunity to study the earliest stages of their development.

The first thing we observe is that the medullary corpuscles become crowded instead of exhibiting pale fields of myxomotous basis-substance between them. They also increase in size, some of them being as large as colorless blood corpuscles, others are two or three times as large and exhibit indistinct nuclei and nucleoli under comparatively low powers of the microscope. Besides these corpuscles there are also seen, not infrequently, clusters of larger size of a granular mass with a varying amount of nuclei, and in addition small glistening corpuscles between the nucleated ones of a more homogeneous structure and with a higher degree of refraction of light than is usual with medullary corpuscles.

By magnifying this portion of the section of the embryo of the chick about 1200 diameters, the reticular structure of the medullary corpuscle is plainly visible. All the corpuscles are connected with each other by means of threads of living matter traversing the light interstices between the corpuscles. The small granular or globular bodies are also connected with each other and with the neighboring corpuscles in the same way.

The first step towards the formation of muscle is that the points of intersection of the medullary corpuscles become slightly enlarged and arrange themselves in rows vertically to the long axis of the

corpuscle. Sometimes this arrangement into rows occurs first in the nucleus, afterwards in the body of the medullary corpuscle. The rule, however, is that the medullary corpuscle in portions of its body, or in its whole body, takes on this arrangement into rows, whereby the double contour of the nucleus representing its shell becomes transformed into similar granules that pervade the main row and which now deserve the name of sarcous elements. I think I may be allowed to say that this important fact has been settled by my observations.

The truth is, the points of intersection of the reticulum, the so-called granules of the protoplasm, are directly transformed into sarcous elements, and no other change takes place except a slight enlargement of the granules and their arrangement into rows. The delicate threads interconnecting the granules likewise assume a regular arrangement in a longitudinal and transverse direction, interconnecting the sarcous elements both ways. If we bear in mind that the point of intersection and the connecting threads are formations of living matter, the bioplasson formation of Louis Elsburg, we readily realize the transformation of originally irregularly arranged granules into regularly arranged sarcous elements. This was shown in my paper on the muscles of the lobster, read before this Society in 1882, and previously by C. Heitzman.

An increase of nourishing matter will suffice to transform the original granules into rod-like sarcous elements, although not the slightest idea can be given as to why this takes place. As both the nucleoli and the shell of the nucleus are known to be formations of living matter, their participation in the formation of sarcous elements may be understood.

Contractility is a property of living matter in general and it is the same in the medullary corpuscle or in the muscle, only it is more powerful in the latter tissue. As previously mentioned, a number of oblong or spindle-shaped medullary corpuscles may be seen intermixed with the granular one. The previous formations first exhibit the transverse striations, hence the conclusion becomes admissible that globular medullary corpuscles in the process of being transformed into muscle tissue become spindle-shaped. These spindle-shaped corpuscles after assuming the regular arrangement into

sarcous elements, split up into a number of delicate spindle-shaped fibrillæ, groups of which are seen freely mixing with globular and comparatively little changed medullary corpuscles.

As the union between the fibers and the medullary corpuscles is nowhere interrupted, owing to the presence of the delicate threads of living matter between all the concurrent elements, we may understand how a number of fibrillæ may arrange themselves into what we call a muscle fiber, the formerly called muscle bundle. It is highly probable, besides, that the splitting up into fibrillæ is due to the preservation of the specimen in a solution of chromic acid and in alcohol, the latter of which is used to bring out the longitudinal fibrillation more plainly.

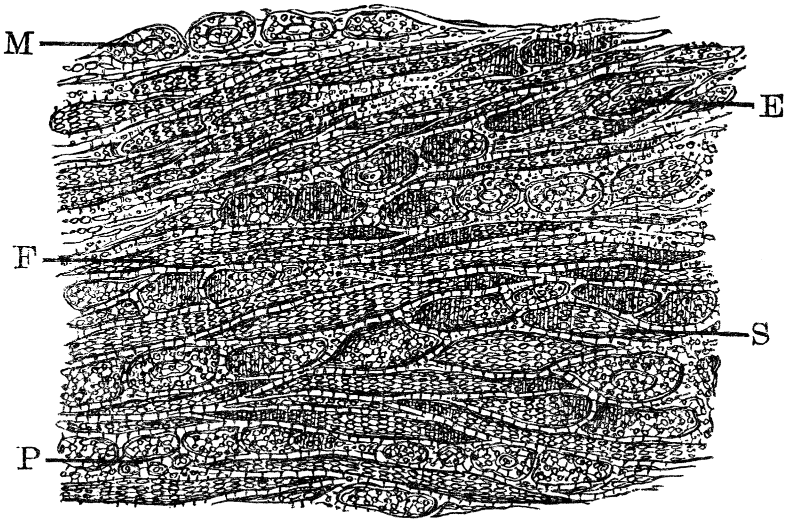
A large number of the nuclei do not take a part in the formation of sarcous elements, but remain unchanged, either at the periphery of a muscle bundle or in its center. The younger the animal the larger the number of such undifferentiated nuclei.

From this regular occurrence a slight deviation may be caused by the fact that sometimes the medullary corpuscles split up into delicate spindles before rows of sarcous elements begin to show themselves. In this way a striking resemblance is established between fibrous cartilage tissue and striped muscle. In the former the reticulum of living matter remains irregular and the meshes are transformed into a glue yielding basis-substance. In the latter the reticulum of living matter becomes highly developed and its meshes contain some nitrogenous liquid substance, perhaps identical with that present in protoplasm in general.

Multinuclear bodies, by becoming elongated, spindle-shaped, split into a number of delicate spindles, and arranging themselves into sarcous elements are directly transformed into the primitive muscle bundles of our early microscopists, or muscle fiber of the present nomenclature.

The same features that I have discovered in the embryo of the chick at five days I have seen in the muscles of the tongue and lower jaw of the human embryo of the seventh or eighth week, but in the third month of the human embryo there are found very long muscle fibrillæ and it is with difficulty that the order of development can be traced.

As to the connection of the sarcous elements both in the longitudinal and transverse sections, it is of interest to note that quite recently two eminent Europeans, histologists, Bremmer and Retzius Key, of Sweden, have confirmed their presence. Thus a certain harmony has been established on this question between American and European microscopists, the former being the original observers.



First formed striped muscle fibers in embryo of chicken after five days' incubation. X 1200. Unstained.

E.—Medullary corpuscle, elongated, the granules being the points of intersection of the reticulum slightly enlarged and beginning to be arranged in rows.

P.—Protoplasm with several small nuclei, perhaps the future perimisums.

S.—Medullary corpuscles, spindle-shaped with distinct rows of sarcous elements—the points of intersection of the reticulum.

F.—Fully developed muscle fiber partly coalesced into one body.

Theodore Margo * was the first to indicate the correct way in which muscle fibers are developed. Previously the notion prevailed, according to Schwann, that each fibrilla is an enormously elongated cell. Margo demonstrated that a number of so-called cells for which he suggested the term sarco-plasts or flesh-formers, through their coalescence, gave the result of what are known to-day to be muscle fiber.

* Denkschriften der Keiserlichen Akademie der Wissenschaften, Band xx., 1862.

Since Bowmann (1849) we know that the longitudinal fibrillæ are merely secondary or even artificial formations. The connections of the sarcous elements, in the earliest stages of formation of striped muscle, and the direct transformation of the granular of protoplasm into prisms of sarcous elements, were not known to any previous observers.

Albert Kölliker, * in the chapter on the development of the muscular system, speaks with great fullness of the morphology and chronology of the development of striped muscle, but I find no mention of its histology or of the histological process of its first unfolding.

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* Entwickelungs Geschichte des Menschen: Leipsic, 1879.